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LISTS OF SPECIES

List of Plants with Galls Induced by Insects from the UNILAVRAS/Boqueirão Biological Reserve, Ingaí, state of Minas Gerais, Brazil

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ABSTRACT: Tumors caused on vegetal tissues, named galls or cecidiens, may occur due to the action of several organisms such as bacteria, viruses, nematodes, fungi and insects. The main inductors are insects and this is a highly complex kind of herbivory. Most of the insects that induce the formation of galls are specific to their host plant, i.e., they do it only in a species or in a closed relation of a group of host species. From August 2007 to July 2009 a survey on galls was carried out in the UNILAVRAS/Boqueirão Biological Reserve, located in the municipality of Ingaí/MG, in the environments Cerrado, rocky field and riparian forest. Fifth-seven galls morphotypes were registered in plant organs, distributed on 18 families. The vegetal families that presented the highest amount of galls were Myrtaceae, Asteraceae e Melastomataceae. Galls were observed on the following parts of the plant: leaves, stem, fruit and petiole and the leaves represented the most attacked organ by cecidogens.

INTRODUCTION

Tumors caused on vegetal tissues, named galls or cecidiens may occur due to the action of several organisms such as bacteria, viruses, nematodes, fungi and insects (Borges 2006). The main inductors are insects and this is a highly complex kind of herbivory. Gall insects surpass mechanical and chemical defenses of host plants and stimulate the meristems to proliferate and differentiate into galls. These insects are selective when it comes to the plants they explore, obtaining at the same time food and physical protection against environmental extreme conditions and several natural enemies (Price *et al.* 1987; Fernandes and Price 1992).

The formation of galls comprises a complex series of interactions among the plant tissues and other organisms that live on it (Shorthouse and Rohfritsh 1992). It represents fantastic adaptations of certain insects that feed on plants and evolved under the influence of selective pressure made by various environmental factors. From the ecological point of view, galls allow the cecidogens to colonize and improve their distribution in different environments (Souza *et al.* 2000). Humidity, for example, is a restrictive factor; xeric environments seem to be more propitious to the appearance of more galls. In contrast, the intensity of their attack may cause the death of the affected plants (Fernandes and Martins 1985).

Although all the studies about galls show that leaves and stems are the most affected organs by cecidogens (Gonçalves-Alvin and Fernandes 2001; Maia and Fernandes 2004; Fernandes and Negreiros 2006; Araújo *et al.* 2007; Fernandes *et al.* 2009; Maia and Azevedo 2009), galls may be found from roots to the apical meristem, including vegetative and reproductive organs. Furthermore, they do not follow a defined pattern, but they present several morphological and anatomical types and various colors (Fernandes *et al.* 1995).

The damages caused by cecidogens with the destruction of healthy tissues and the competition with other vegetal tissues for resource, are evident. Moreover, galls can weaken host plants, making difficult their development and providing opportunity to the attack of other organisms that are considered plagues (Borges 2006).

The main insects that induce galls belong to the orders Diptera, Hemiptera (Heteroptera and Homoptera), Lepidoptera, Coleoptera and Hymenotera, according with Urso-Guimarães and Scareli-Santos (2006), Maia *et al.* (2008) and Coelho *et al.* (2009). Most of them are specific to their host plant (Maia 1996), i.e., they induce the formation of galls only in a species or in a closed relation of a group of host plants (Shorthouse and Rohfritsch 1992).

Many authors studied the occurrence and characterization of insect galls in several environments. Fernandes *et al.* (1988) and Urso-Guimarães and Scareli-Santos (2006) related the occurrence of galls and made their characterization on Brazilian Cerrado. Gonçalves-Alvin and Fernandes (2001) related 92 galls morphotypes of insects galls in 28 vegetal families from the Cerrado while Urso-Guimarães *et al.* (2003) found 37 gall species in 16 vegetal families also from the Cerrado. Furthermore, Maia and Fernandes (2004) found 137 types of insect galls in 30 families. Ferreira *et al.* (2007) made comparisons between galls from Cerrado and from other environments. Three fragments of a Seasonally Dry Tropical were studied and found 92 galls morphotypes in 51 host plant species of 19 families (Coelho *et al.* 2009). Maia *et al.* (2008) investigated restinga environments and found 233 galls on 123 plant species and 48 families.

Studies on Cerrado, such as the one carried out by Ferreira *et al.* (2007), related the incidence of galls as an environmental consequence, what is characteristically propitious to their development, because they are more common where the plants need more nutritional resources.

Fernandes and Martins (1985) give the example of how humidity is a restrictive factor; xeric environments seem to be more propitious to the appearance of more galls. According to Fernandes and Price (1992), cecidogens suffer a higher selective pressure put by natural enemies in dry environments, what can raise significantly their number. Surveys about entomogen galls, comparing several environments, prove the existence of a higher amount of galls in Cerrado (Gonçalves-Alvin and Fernandes 2001; Urso-Guimarães *et al.* 2003; Araújo *et al.* 2007; Ferreira *et al.* 2007; Coelho *et al.* 2009).

The most interesting thing about studying interactions between gall inductors and their respective plants is the learning about selectivity of insects, regarding the vegetal that best provides food and conditions to survive. Each insect species adapts to the chemical and physical defenses of the plant, and they use them for their own benefit, thus improving their reproductive success.

The UNILAVRAS/Boqueirão Biological Reserve (Ingaí, MG) has a great diversity of insect galls. There are different ecosystems inside Cerrado biome, and this work aims to know the main host plants and describe macroscopically the morphology of the galls found in three phytophysiognomies of this reserve (Cerrado, rocky field and riparian forest).

Materials and Methods

Data collection was made in UNILAVRAS/Boqueirão Biological Reserve, located in Ingaí, southeastern Minas Gerais State, Brazil (21°20'47" S, 44°59'27" W). .It has an area of 160 hectares, an altitude that ranges from 1100m to 1250m.

Field visits occurred weekly and three phytophysiognomies (Cerrado, rocky fields and riparian forest) of the reserve were chosen randomly from August 2007 to July 2009. The environments were covered for about four hours a day, observing all the plants had galls during the journey traveled. Were analyzed herbs, shrubs and small trees. Samples of each vegetal species that contained galls on the leaves, fruits or stem were collected. From these samples, exsiccates were set up and put in the Herbarium Luna of Centro Universitário de Lavras. The identification of the vegetal species was made by means of comparison with specimens from Herbarium of Lavras (UNILAVRAS) and also Herbarium ESAL (UFLA – Universidade Federal de Lavras) and with the help of researcher Dra. Vivette Appolinário R. Cabral.

All the found galls were photographed with the aid of a digital camera. Samples of branches with galls were collected, kept in plastic bags, labeled individually and taken to the Laboratory of Zoology of UNILAVRAS, which allowed monitoring them to obtain their inductors, and identification was performed with the help of the researcher Ms. Ricardo Lima do Tanque. It was also performed in the Laboratory, galls morphological characterization made according to Fernandes *et al.* (1988), Urso-Guimarães and Scareli-Santos (2006) and Maia *et al.* (2008), based on their color, form, size and localization in the plant.

Results and Discussion

Fifty seven different morphotypes of insect galls were found in 43 species of plants distributed on 18 different families. Only plants that were identified by their gender are detailed (Table 1). The vegetal families that presented the highest amount of galls were Asteraceae (n= 6), Myrtaceae (n= 5) and Melastomataceae (n= 3). The same families also were reported to have the greatest diversity of galls in Tiradentes, Minas Gerais (Maia and Fernandes 2004) and the family Myrtaceae, in the work of Oliveira and Maia (2005), on Grumari sandbank, Rio de Janeiro. In the Cerrado, these families were also found in results of other studies (Maia and Fernandes 2004, Urso-Guimarães and Scareli-Santos 2006). Although these families often have a greater number of plants with galls, these results may vary according to each studied environment and with the composition of plants.

Galls were observed on the following parts of the plant: leaves, stem, fruit and petiole (Table 1). No galls were found on flowers, although they were observed. Leaves represented the most attacked organ by cecidogens (n = 22). Similar results were found by Maia and Fernandes 2004; Oliveira and Maia 2005; Fernandes and Negreiros 2006; Maia *et al.* 2008. The second most attacked organ was the stem (n = 12). Galls developed on fruits and petioles were also found, but in a considerably smaller quantity. Galls on fruit occurred in *Myrcia guianensis* (Myrtaceae) and on petiole in *Miconia* sp (Melastomataceae). Spherical (n = 15) and globular galls (n = 12) predominated (Table 1). Most of the galls presented glabrous pubescence (n = 23).

Rocky fields presented the smallest quantity of host plants, with only 2 species; Cerrado and riparian forest presented 17 the both (Table 1). Similar results were found on the works of Ferreira *et al.* (2007) and Fernandes and Martins (1985), which state that dry climates and environments lacking nutrients provide better conditions for galls formation, due to the need of these cecidogens to find a propitious environment to their development.

Based on these results, this study contributes to more information about the entomogenous galls and their inducers in Cerrado. The results also show a great ecological potential of the region, because they found several host plants and richness of gall-inducing insects.

Table 1. Morphological description of insect galls from UNILAVRAS/Boqueirão Biological Reserve, Ingaí, Minas Gerais, Brazil.

HOST PLANT	GALL MAKER	ORGAN	SHAPE	COLOUR	PUBESCENCE	CHAMBERS	AMBIENT	REFERENCE
Annonaceae								
Duguetia furfuraceae (St. Hill) Benth e Hook	Not identified	Leaf	Globulous	Green/Brown	Glabrous	Various	Cerrado	Figure 1A
Apocynaceae								
Prestonia tomentosa R. Br.	Cecidomyiidae	Leaf	Spherical	Yellow	Hairy	1	Cerrado	Figure 1B
Asteraceae								
Baccharis dracunculifolia D.C	*Baccharopelma dracunculifoliae* (Hemiptera)	Leaf	Fusiform	Green	Glabrous	1	Cerrado	Figure 1C
Eremanthus erythropappus (D.C.) MacLush	Not identified	Leaf	Globulous	Green	Glabrous	1	Rocky fields	Figure 5A
	Not identified	Stem	Spherical	Brown	Glabrous	1	Rocky fields	Figure 5B
Eremanthus sp.	Not identified	Stem	Globulous	Brown	Glabrous	1	Cerrado	Figure 2A
Gochnatia barrosii Cabrera	Cecidomyiidae	Leaf	Globulous	Yellow	Hairy	Various	Cerrado	Figure 1D
Gochnatia polymorpha (Less.) Cabrera	Cecidomyiidae	Stem	Spherical	Yellow	Hairy	1	Cerrado	Figure 2B
Mikania sp.	Cecidomyiidae	Leaf	Conical	Green	Glabrous	1	Riparian Forest	Figure 6A
Burseraceae								
Protium heptaphyllum Aubl. Marchand	Cecidomyiidae	Leaf	Conical	Red	Glabrous	1	Riparian Forest	Figure 6B
	Cecidomyiidae	Leaf	Fusiform	Green	Hairy	1	Riparian Forest	Figure 6C
Combretaceae								
Terminalia argentea	Not identified	Leaf	Spherical	White/ purple	Hairy	1	Cerrado	Figure 1E
Convolvulaceae								
Ipomoea alba L.	Not identified	Stem	Spherical	Brown	Glabrous	1	Riparian Forest	Figure 7A
Erythroxylaceae								
Erythroxylon suberosum A. St.-Hill	*Myrciariamyia* admirabilis (Diptera, Cecidomyiidae)	Leaf	Globulous	Brown	Hairy	Various	Cerrado	Figure 1F
	Not identified	Stem	Globulous	Brown	Glabrous	Various	Cerrado	Figure 2C
Euphorbiaceae								
Croton sp.	Cecidomyiidae	Leaf	Spherical	Brown	Hairy	1	Cerrado	Figure 1G
	Cecidomyiidae	Leaf	Spherical	White	Hairy	1	Cerrado	Figure 1H
	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	1	Cerrado	Figure 1I
	Not identified	Stem	Globulous	Brown	Hairy	1	Cerrado	Figure 2D
Fabaceae								
Machaerium aculeatum Raddi	*Anadiplosis* sp. (Diptera)	Stem	Spherical	Green	Hairy	1	Riparian Forest	Figure 7B
Melastomataceae								
Miconia sp. 1	Lepidoptera	Leaf	Spherical	Green/Red	Hairy	1	Riparian Forest	Figure 6D
	Lepidoptera	Petiole	Spherical	Green/Red	Hairy	1	Riparian Forest	Figure 9
Miconia sp. 2	Not identified	Leaf	Globulous	Pink	Hairy	1	Riparian Forest	Figure 6E
	Not identified	Stem	Globulous	Brown	Glabrous	Various	Riparian Forest	Figure 7C
Miconia sp. 3	Not identified	Stem	Fusiform	Brown	Glabrous	1	Riparian Forest	Figure 7D
Myrtaceae								
Myrcia guianensis	Cecidomyiidae	Fruit	Globulous	Red	Glabrous	1	Cerrado	Figure 4
Myrcia splendens (SW.) DC.	Cecidomyiidae	Leaf	Spherical	Green/Red	Glabrous	1	Riparian Forest	Figure 6F
	Hymenoptera	Stem	Fusiform	Brown	Glabrous	Various	Riparian Forest	Figure 8A
Eugenia sp. 1	Not identified	Leaf	Fold leaf	Green	Glabrous	1	Cerrado	Figure 1J
Eugenia sp. 2	Cecidomyiidae	Leaf	Conical	Yellow	Glabrous	1	Riparian Forest	Figure 6G
	Not identified	Leaf	Spherical	Green	Glabrous	1	Riparian Forest	Figure 6H
	Not identified	Stem	Globulous	Brown	Glabrous	1	Riparian Forest	Figure 8B
Eugenia sp. 3	Not identified	Leaf	Spherical	Yellow	Glabrous	1	Riparian Forest	Figure 6I
Smilacaceae								
Smilax sp.	Not identified	Leaf	Globulous	Green	Glabrous	1	Riparian Forest	Figure 6J
Solanaceae								
Solanum lycocarpum St. Hill.	*Collabismus clitellae* (Curculionidae)	Stem	Globulous	Brown	Glabrous	Various	Cerrado	Figure 3
Verbenaceae								
Lippia lupulina Cham.	Not identified	Leaf	Spherical	Yellow	Glabrous	1	Cerrado	Figure 1K

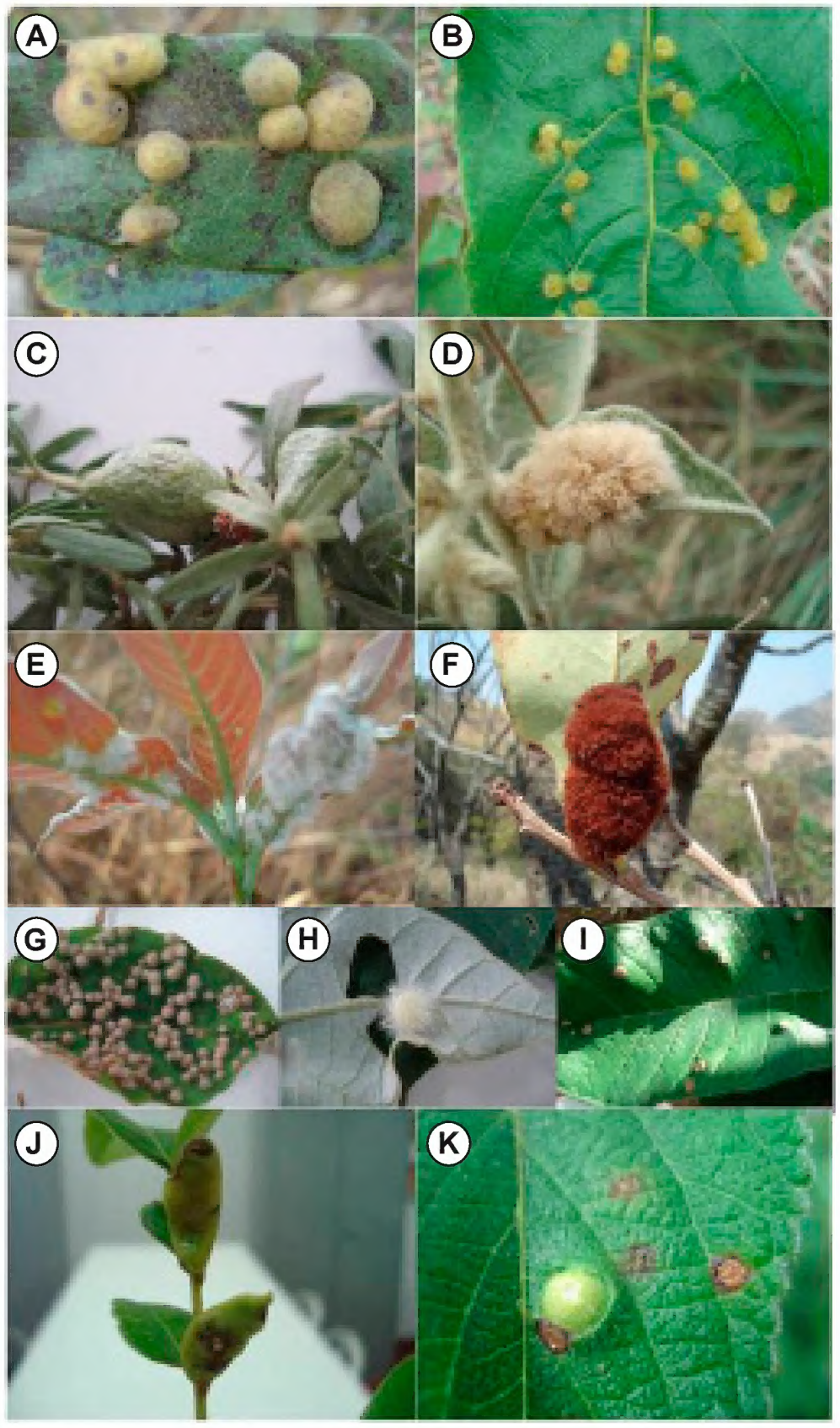

Figure 1. Leaf galls on Cerrado plants: (A) *Duguetia furfuraceae* (Annonaceae); (B) *Prestonia tomentosa* (Apocynaceae); (C) *Baccharis dracunculifolia* (Asteraceae); (D) *Gochnatia barrosii* (Asteraceae); (E) *Terminalia argentea* (Combretaceae); (F) *Erythroxylon suberosum* (Erythroxylaceae); (G, H and I) *Croton* sp. (Euphorbiaceae); (J) *Eugenia* sp.1 (Myrtaceae), (K) *Lippia lupulina* (Verbenaceae).

Figure 2. Stem galls on Cerrado plants: (A) *Eremanthus* sp. (Asteraceae); (B) *Gochnatia polymorpha* (Asteraceae); (C) *Erythroxylon suberosum* (Erythroxylaceae); (D) *Croton* sp. (Euphorbiaceae).

Figure 3. Stem galls on Cerrado plant: *Solanum lycocarpum* (Solanaceae).

Figure 4. Fruit gall on Cerrado plant: *Myrcia guianensis* (Myrtaceae).

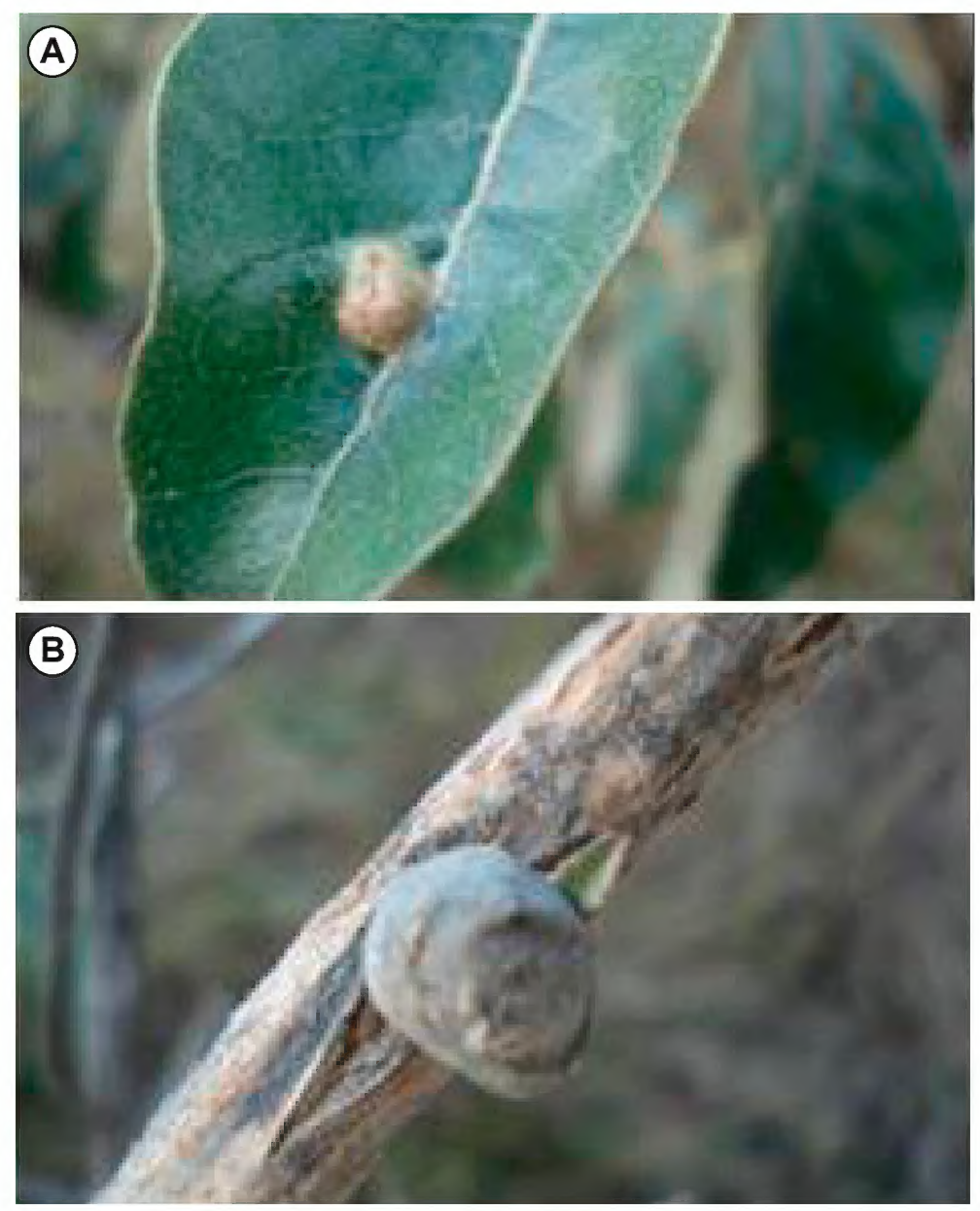

Figure 5. Leaf (A) and stem (B) galls on Rocky fields plants: *Eremanthus erythropappus* (Asteraceae).

Figure 6. Leaf galls on Riparian Forest plants: (A) *Mikania* sp. (Asteraceae); (B and C) *Protium heptaphyllum* (Burseraceae); (D) *Miconia* sp.1 (Melastomataceae); (E) Miconia sp.2 (Melastomataceae); (F) *Myrcia splendens* (Myrtaceae); (G and H) *Eugenia* sp. 2 (Myrtaceae); (I) *Eugenia* sp. 3 (Myrtaceae), (J) *Smilax* sp. (Smilacaceae).

Figure 7. Stem galls on Riparian Forest plants: (A) *Ipomoea alba* (Convolvulaceae); (B) *Machaerium aculeatum* (Fabaceae); (C) *Miconia* sp.1 (Melastomataceae); (D) *Miconia* sp.2 (Melastomataceae).

Figure 8. Stem galls on Riparian Forest plants: (A) *Myrcia splendens* (Myrtaceae), (B) *Eugenia* sp.2 (Myrtaceae).

Figure 9. Petiole gall on Riparian Forest plant: *Miconia* sp.1 (Melastomataceae).

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